FIG.1

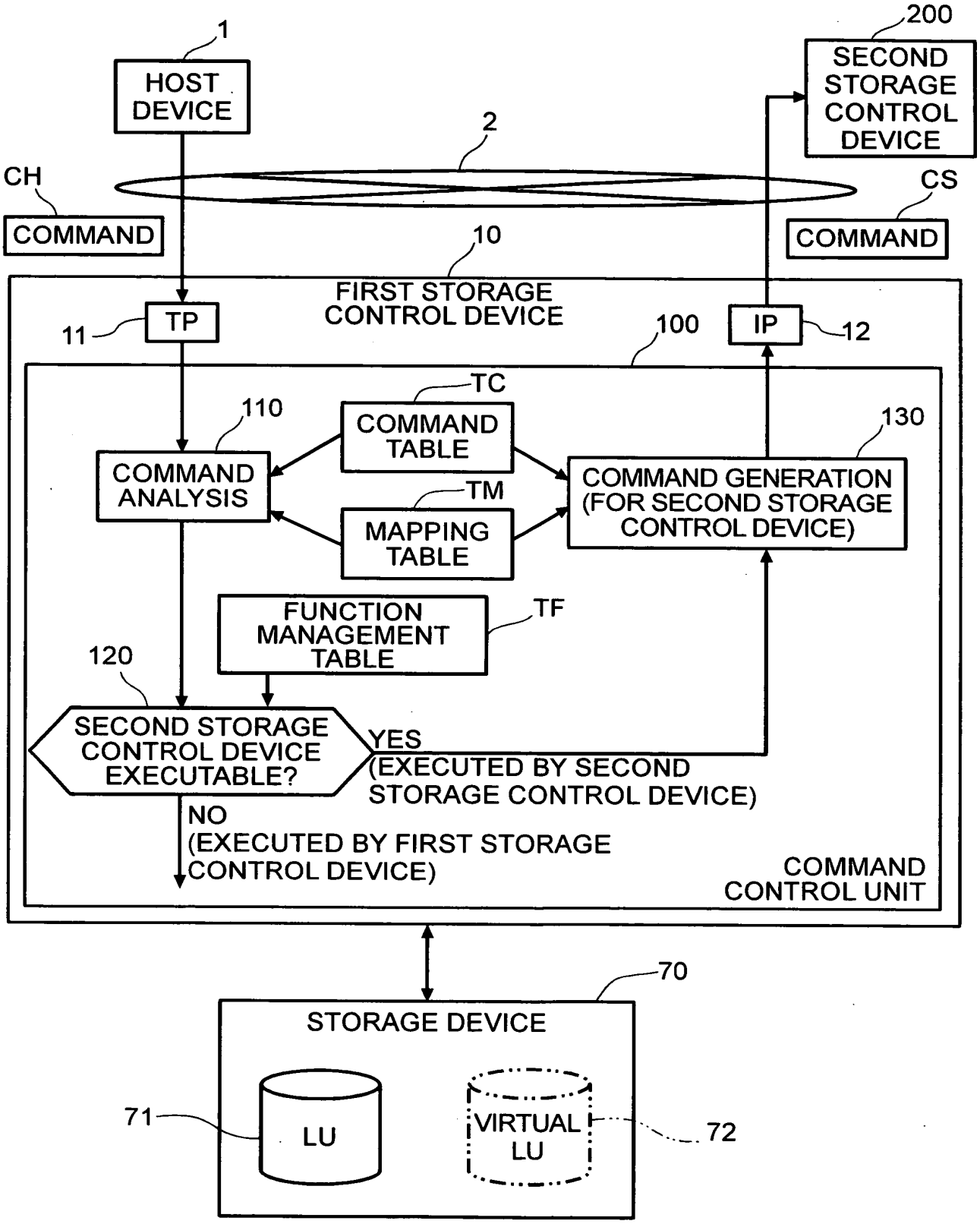

1
HOST DEVICE
200
SECOND STORAGE CONTROL DEVICE
2
CH
COMMAND
CS
COMMAND
10
FIRST STORAGE CONTROL DEVICE
11
TP
100
IP
12
TC
110
COMMAND TABLE
130
COMMAND ANALYSIS
TM
MAPPING TABLE
COMMAND GENERATION (FOR SECOND STORAGE CONTROL DEVICE)
FUNCTION MANAGEMENT TABLE
TF
120
SECOND STORAGE CONTROL DEVICE EXECUTABLE?
YES
(EXECUTED BY SECOND STORAGE CONTROL DEVICE)
NO
(EXECUTED BY FIRST STORAGE CONTROL DEVICE)
COMMAND CONTROL UNIT
70
STORAGE DEVICE
71
LU
VIRTUAL LU
72

FIG.2

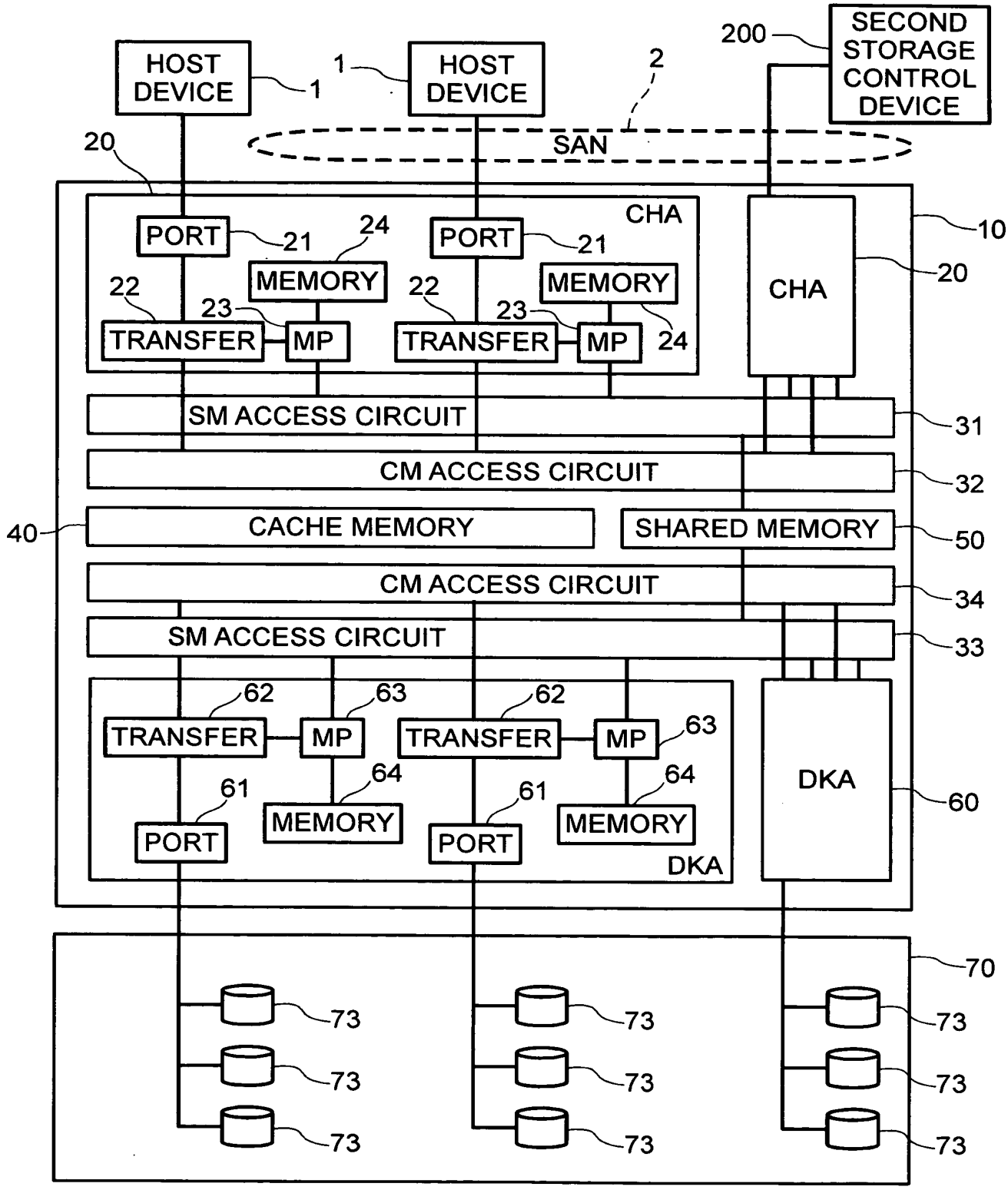

HOST DEVICE
1
HOST DEVICE
2
200
SECOND STORAGE CONTROL DEVICE
SAN
20
CHA
PORT
21
24
PORT
21
MEMORY
MEMORY
22
23
TRANSFER
MP
22
23
TRANSFER
MP
24
10
CHA
20
SM ACCESS CIRCUIT
31
CM ACCESS CIRCUIT
32
40
CACHE MEMORY
SHARED MEMORY
50
CM ACCESS CIRCUIT
34
SM ACCESS CIRCUIT
33
62
63
62
TRANSFER
MP
TRANSFER
MP
63
61
64
61
64
MEMORY
PORT
MEMORY
PORT
DKA
DKA
60
70
73
73
73
73
73
73
73
73
73

FIG.3

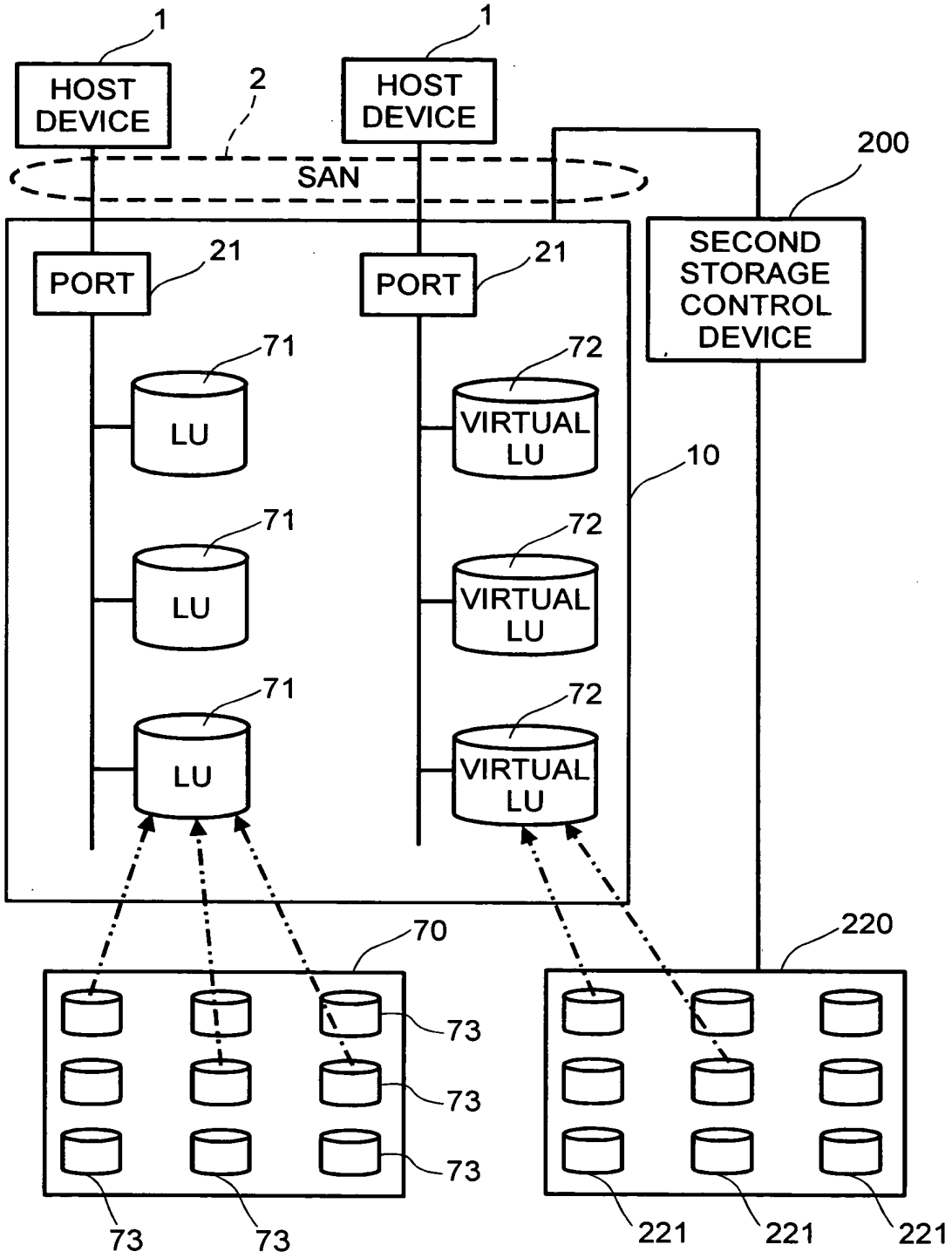

1
1
HOST DEVICE
HOST DEVICE
2
SAN
200
SECOND STORAGE CONTROL DEVICE
PORT
21
PORT
21
71
LU
72
VIRTUAL LU
10
71
LU
72
VIRTUAL LU
71
LU
72
VIRTUAL LU
70
220
73
73
73
73
73
221
221
221

FIG.4

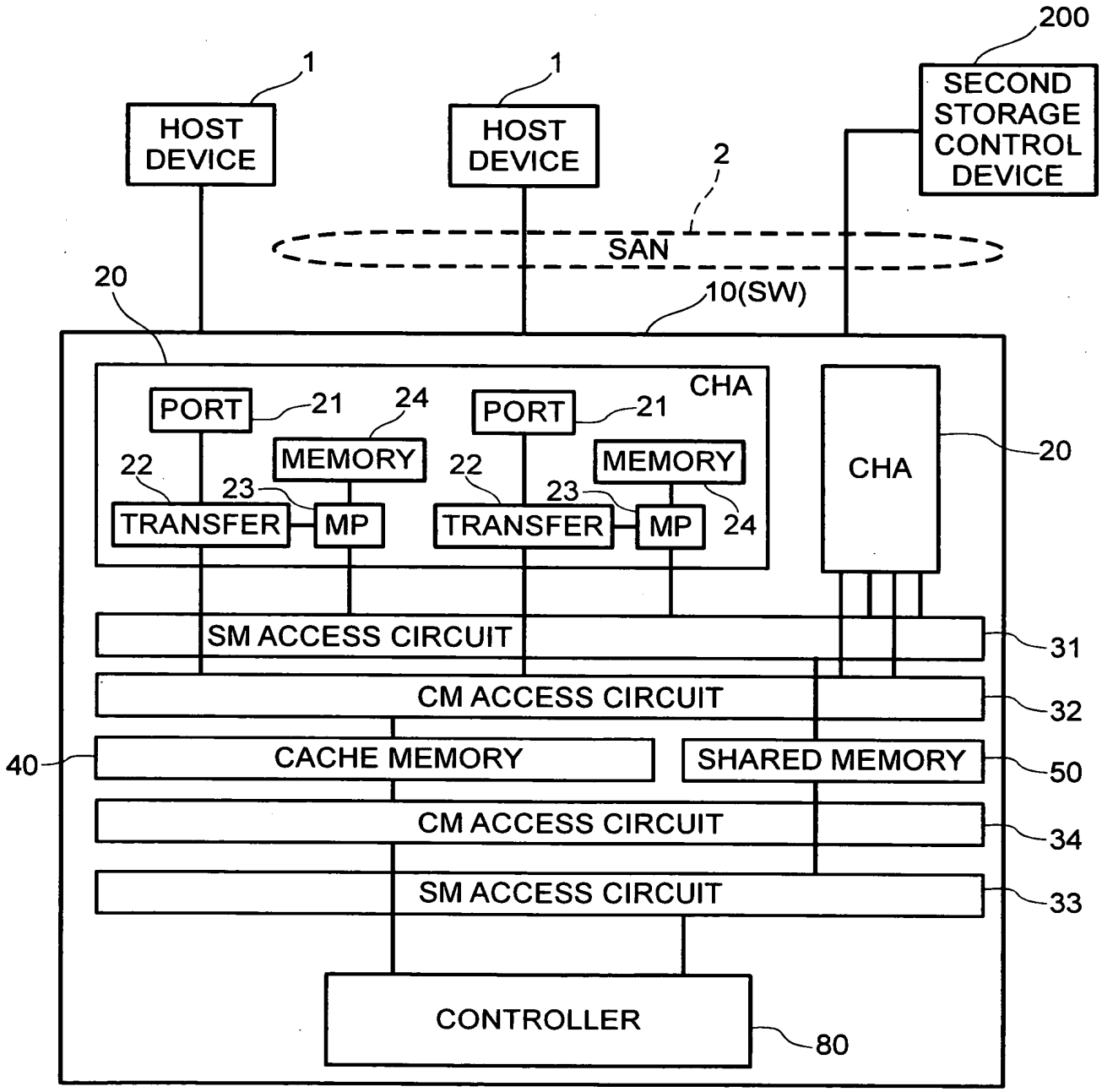

200
1
1
HOST DEVICE
HOST DEVICE
SECOND STORAGE CONTROL DEVICE
2
SAN
20
10(SW)
CHA
PORT
21
24
PORT
21
MEMORY
MEMORY
22
23
22
23
TRANSFER
MP
TRANSFER
MP
24
CHA
20
SM ACCESS CIRCUIT
31
CM ACCESS CIRCUIT
32
40
CACHE MEMORY
SHARED MEMORY
50
CM ACCESS CIRCUIT
34
SM ACCESS CIRCUIT
33
CONTROLLER
80

FIG.5

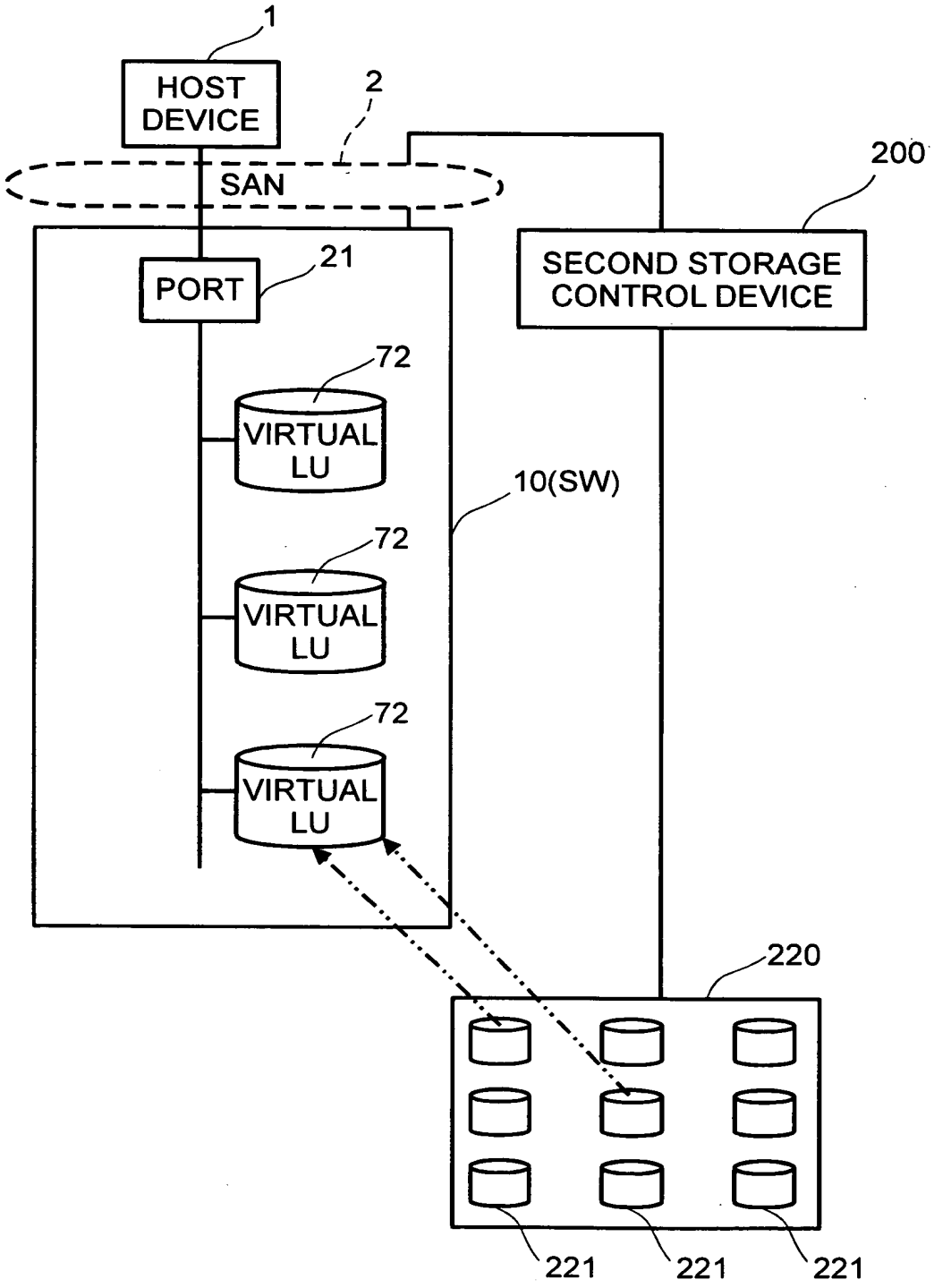

1
HOST DEVICE
2
SAN
200
SECOND STORAGE CONTROL DEVICE
21
PORT
72
VIRTUAL LU
10(SW)
72
VIRTUAL LU
72
VIRTUAL LU
220
221
221
221

FIG.6

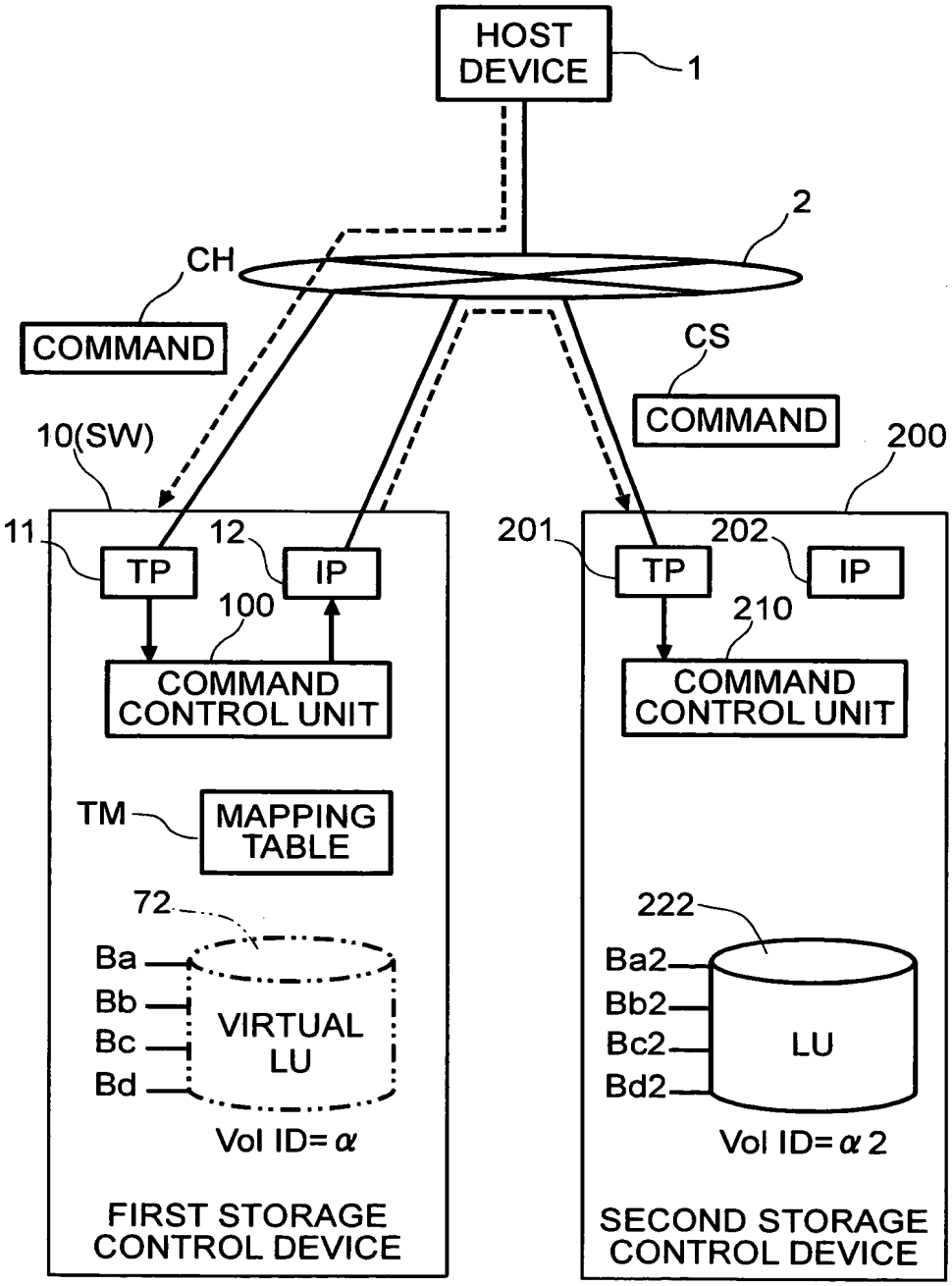

HOST DEVICE
1
2
CH
COMMAND
CS
COMMAND
10(SW)
200
11
12
TP
IP
100
COMMAND CONTROL UNIT
201
202
TP
IP
210
COMMAND CONTROL UNIT
TM
MAPPING TABLE
72
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID=α
FIRST STORAGE CONTROL DEVICE
222
Ba2
Bb2
Bc2
Bd2
LU
Vol ID=α2
SECOND STORAGE CONTROL DEVICE

FIG.7

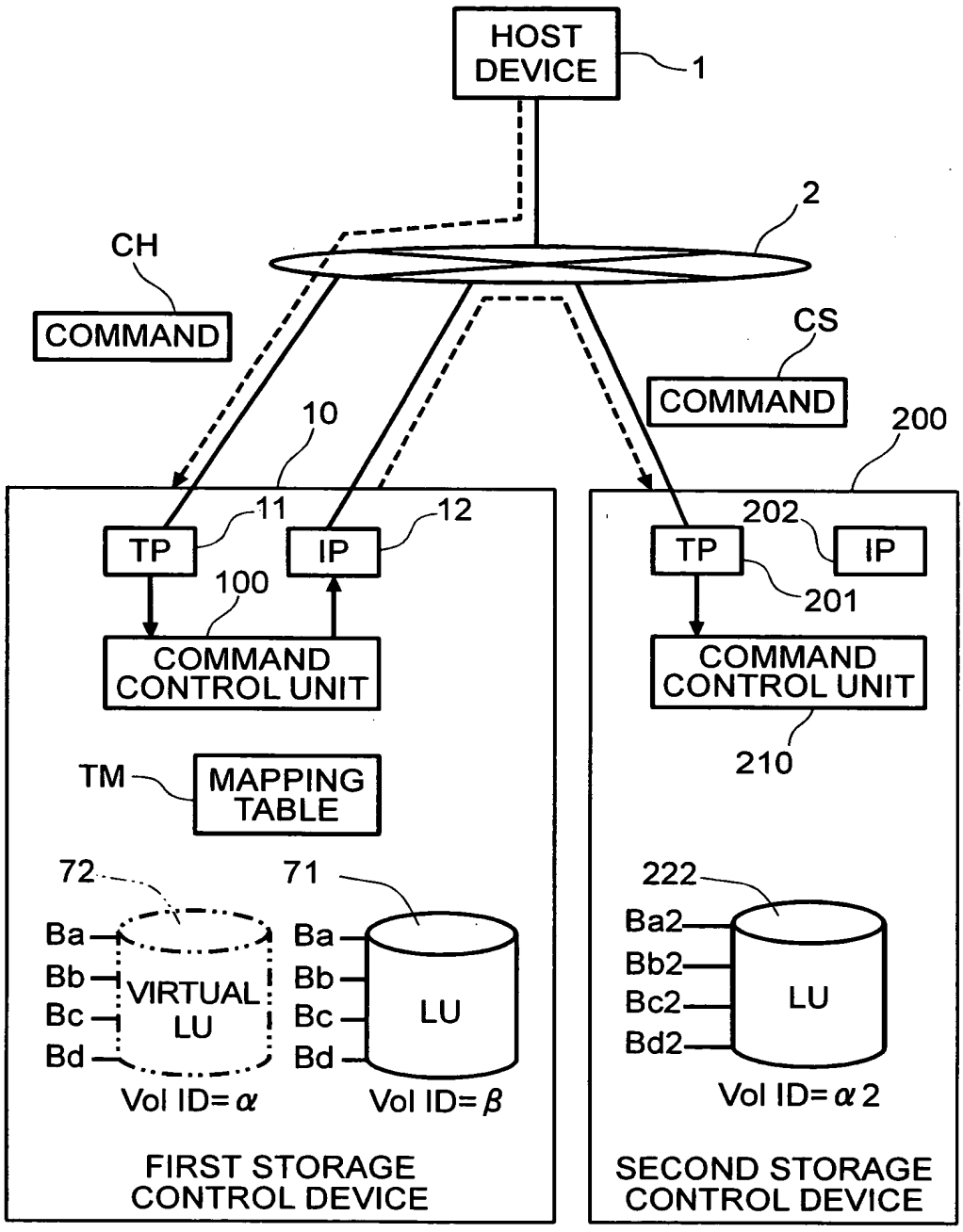

HOST DEVICE
1
2
CH
COMMAND
CS
COMMAND
10
200
11
12
TP
IP
202
TP
IP
100
201
COMMAND CONTROL UNIT
COMMAND CONTROL UNIT
210
TM
MAPPING TABLE
72
71
222
Ba
Bb
Bc
Bd
VIRTUAL LU
LU
Ba2
Bb2
Bc2
Bd2
Vol ID=α
Vol ID=β
Vol ID=α2
FIRST STORAGE CONTROL DEVICE
SECOND STORAGE CONTROL DEVICE

FIG.8

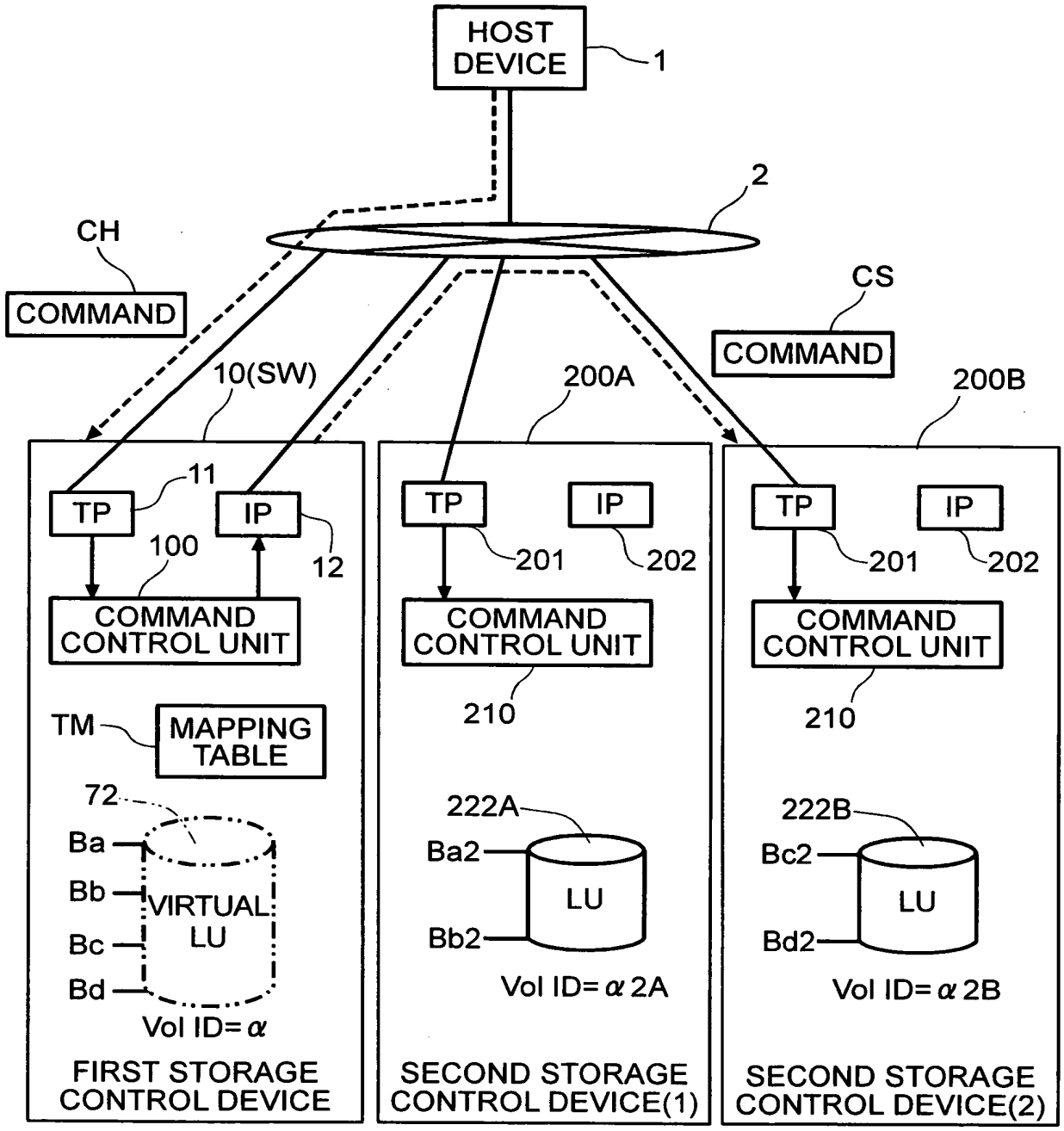

HOST DEVICE
1
2
CH
COMMAND
CS
COMMAND
10(SW)
200A
200B
11
TP
IP
12
100
COMMAND CONTROL UNIT
TM
MAPPING TABLE
72
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID= α
FIRST STORAGE CONTROL DEVICE
TP
IP
201
202
COMMAND CONTROL UNIT
210
222A
Ba2
Bb2
LU
Vol ID= α 2A
SECOND STORAGE CONTROL DEVICE(1)
TP
IP
201
202
COMMAND CONTROL UNIT
210
222B
Bc2
Bd2
LU
Vol ID= α 2B
SECOND STORAGE CONTROL DEVICE(2)

FIG.9

(a) EXAMPLE OF MAPPING TABLE
(IN THE CASE OF FIBER CHANNEL SWITCH)

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
α	Ba	SD2	TP2	α2	Ba2
⋮	⋮	⋮	⋮	⋮	⋮
α	Bd	SD2	TP2	α2	Bd2

(b) EXAMPLE OF MAPPING TABLE
(IN THE CASE OF DISK ARRAY SYSTEM)

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
α	Ba	SD2	TP2	α2	Ba2
⋮	⋮	⋮	⋮	⋮	⋮
α	Bd	SD2	TP2	α2	Bd2
β	Ba	SD1	INTERNAL	—	—
⋮	⋮	⋮	⋮	⋮	⋮
β	Bd	SD1	INTERNAL	—	—

(c) EXAMPLE OF MAPPING TABLE
(IN THE CASE WHERE THERE ARE PLURALITIES OF
SECOND STORAGE CONTROL DEVICES)

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
α	Ba	SD2(1)	TP2(1)	α2A	Ba2
⋮	Bb	SD2(1)	TP2(1)	α2A	Bb2
⋮	Bc	SD2(2)	TP2(2)	α2B	Bc2
α	Bd	SD2(2)	TP2(2)	α2B	Bd2

FIG.10

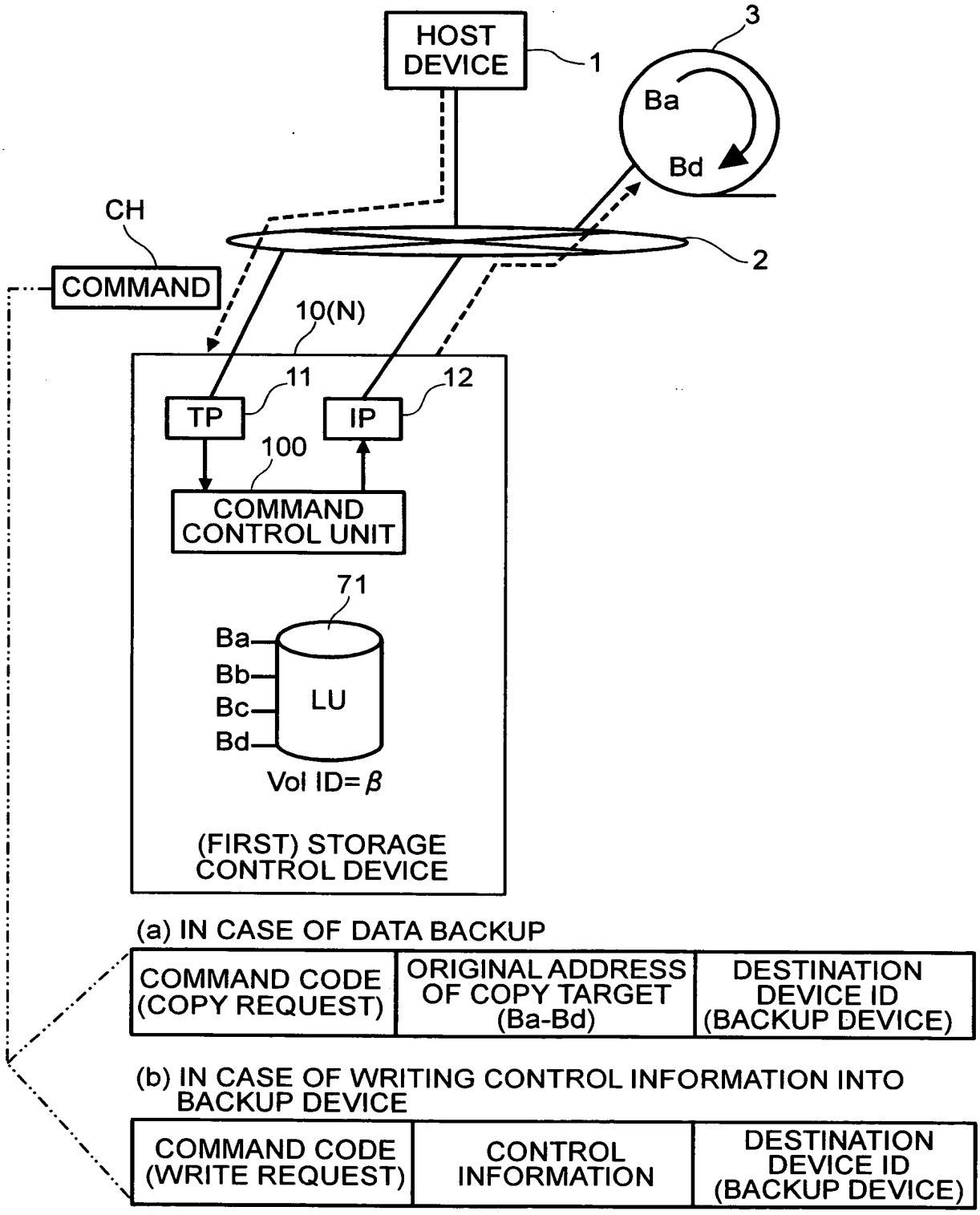
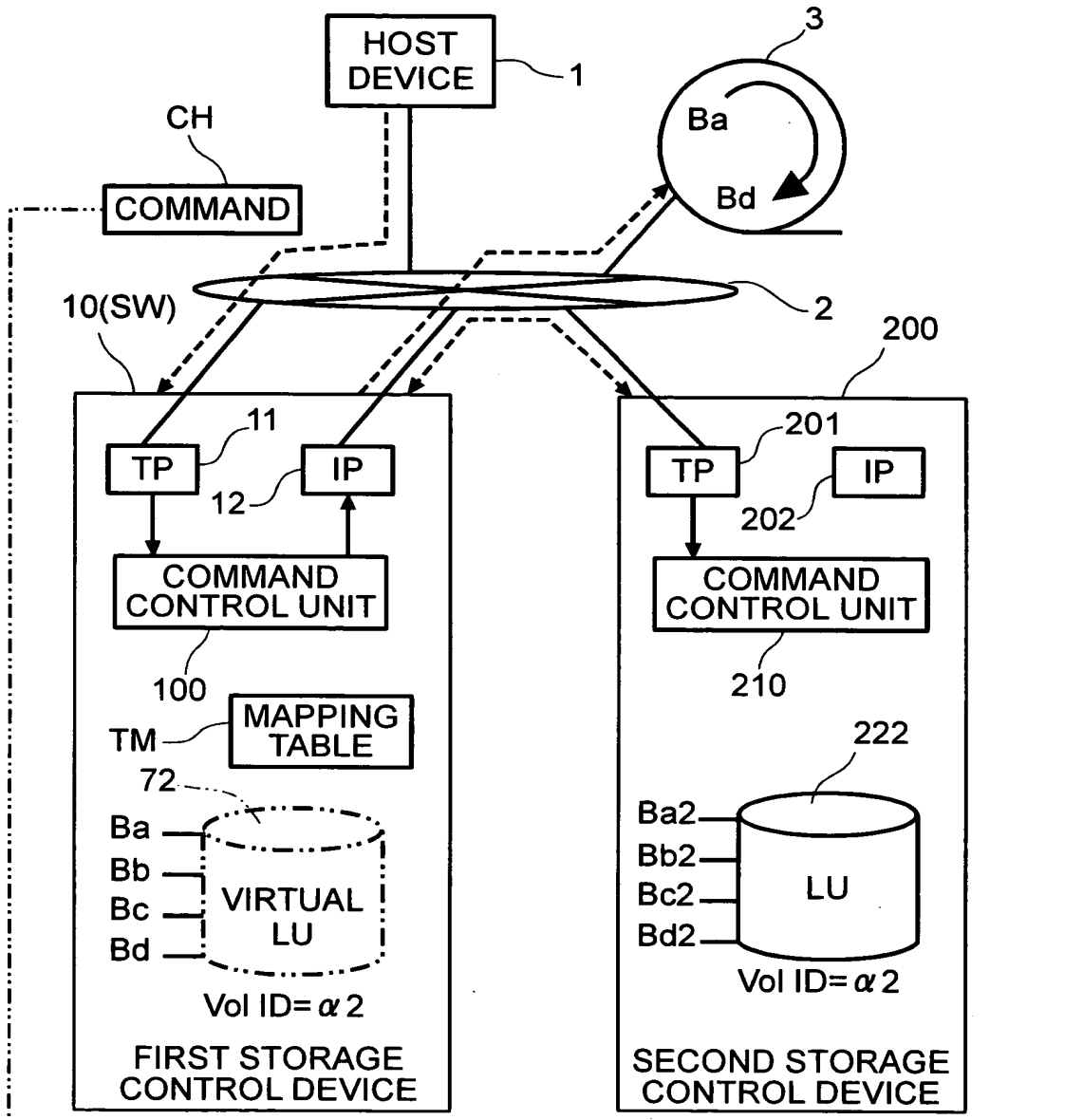

HOST DEVICE
1
3
Ba
Bd
CH
2
COMMAND
10(N)
11
12
TP
IP
100
COMMAND CONTROL UNIT
71
Ba
Bb
Bc
Bd
LU
Vol ID=β
(FIRST) STORAGE CONTROL DEVICE
(a) IN CASE OF DATA BACKUP
COMMAND CODE (COPY REQUEST)
ORIGINAL ADDRESS OF COPY TARGET (Ba-Bd)
DESTINATION DEVICE ID (BACKUP DEVICE)
(b) IN CASE OF WRITING CONTROL INFORMATION INTO BACKUP DEVICE
COMMAND CODE (WRITE REQUEST)
CONTROL INFORMATION
DESTINATION DEVICE ID (BACKUP DEVICE)

FIG.11



(a) IN CASE OF DATA BACKUP

COMMAND CODE (COPY REQUEST)	ORIGINAL ADDRESS OF COPY TARGET (Ba-Bd)	DESTINATION DEVICE ID (BACKUP DEVICE)

(b) IN CASE OF WRITING CONTROL INFORMATION IN BACKUP DEVICE

COMMAND CODE (WRITE REQUEST)	CONTROL INFORMATION	DESTINATION DEVICE ID (BACKUP DEVICE)

FIG.12

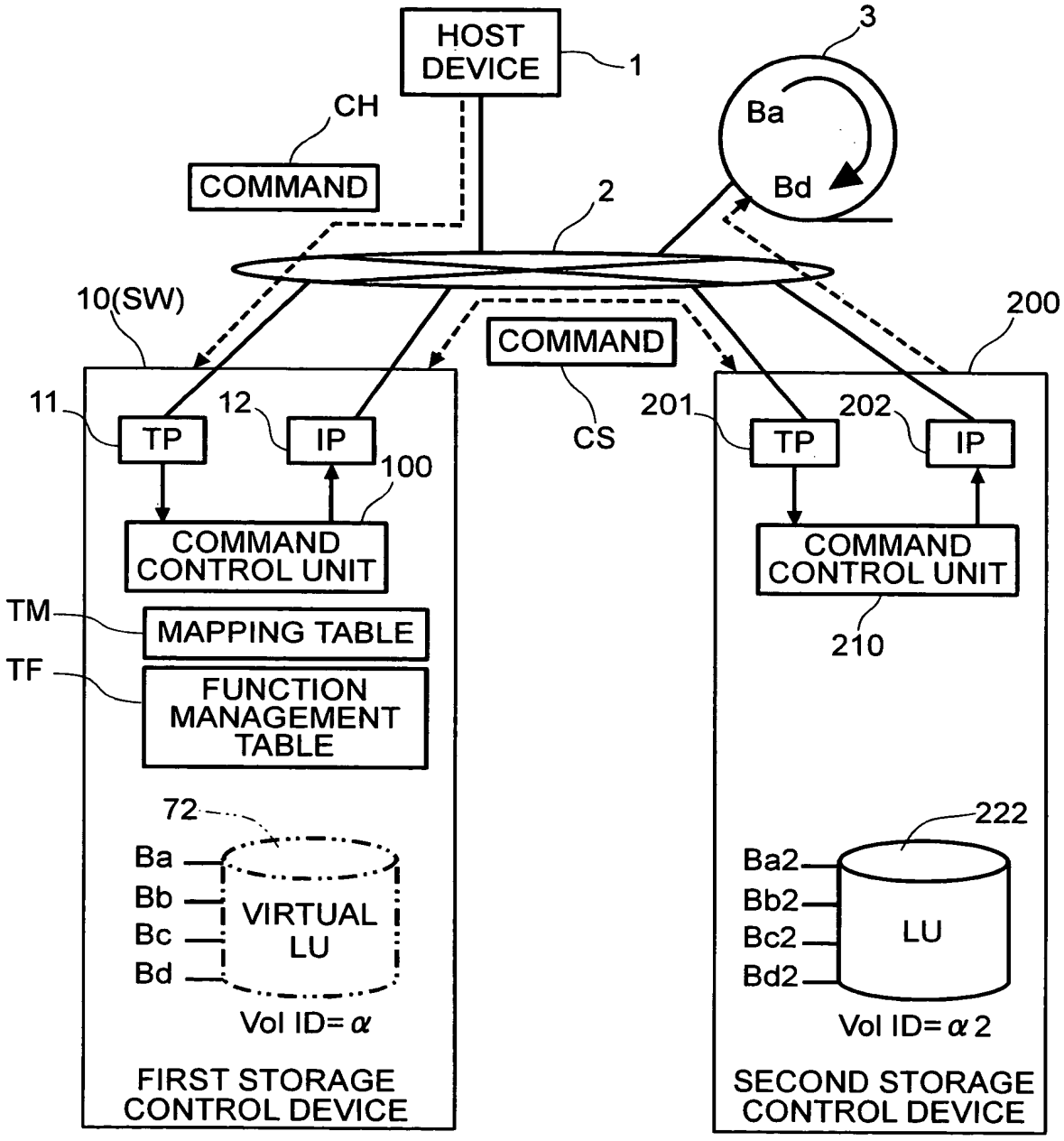

HOST DEVICE
1
3
Ba
Bd
CH
COMMAND
2
10(SW)
200
COMMAND
CS
11
12
201
202
TP
IP
TP
IP
100
COMMAND CONTROL UNIT
COMMAND CONTROL UNIT
210
TM
MAPPING TABLE
TF
FUNCTION MANAGEMENT TABLE
72
222
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID= α
Ba2
Bb2
Bc2
Bd2
LU
Vol ID= α 2
FIRST STORAGE CONTROL DEVICE
SECOND STORAGE CONTROL DEVICE

FIG.13

(a) EXAMPLE OF FUNCTION MANAGEMENT TABLE

TF

DEVICE ID	Port ID	SUPPORT FUNCTION F1	SUPPORT FUNCTION F2	···	SUPPORT FUNCTION Fn
SD2(1)	TP2(1)	POSITIVE	NEGATIVE	···	POSITIVE
⋮	⋮	⋮	⋮	⋮	⋮
SD2(n)	TP2(n)	POSITIVE	POSITIVE	···	NEGATIVE

(b) HOST DEVICE → FIRST STORAGE CONTROL DEVICE

CH

COMMAND CODE (COPY REQUEST)	ORIGINAL ADDRESS OF COPY TARGET (Ba-Bd)	DESTINATION DEVICE ID (BACKUP DEVICE)

(c) FIRST STORAGE CONTROL DEVICE → SECOND STORAGE DEVICE

CS

COMMAND CODE (COPY REQUEST)	ORIGINAL ADDRESS OF COPY TARGET (Ba2-Bd2)	DESTINATION DEVICE ID (BACKUP DEVICE)

FIG.14

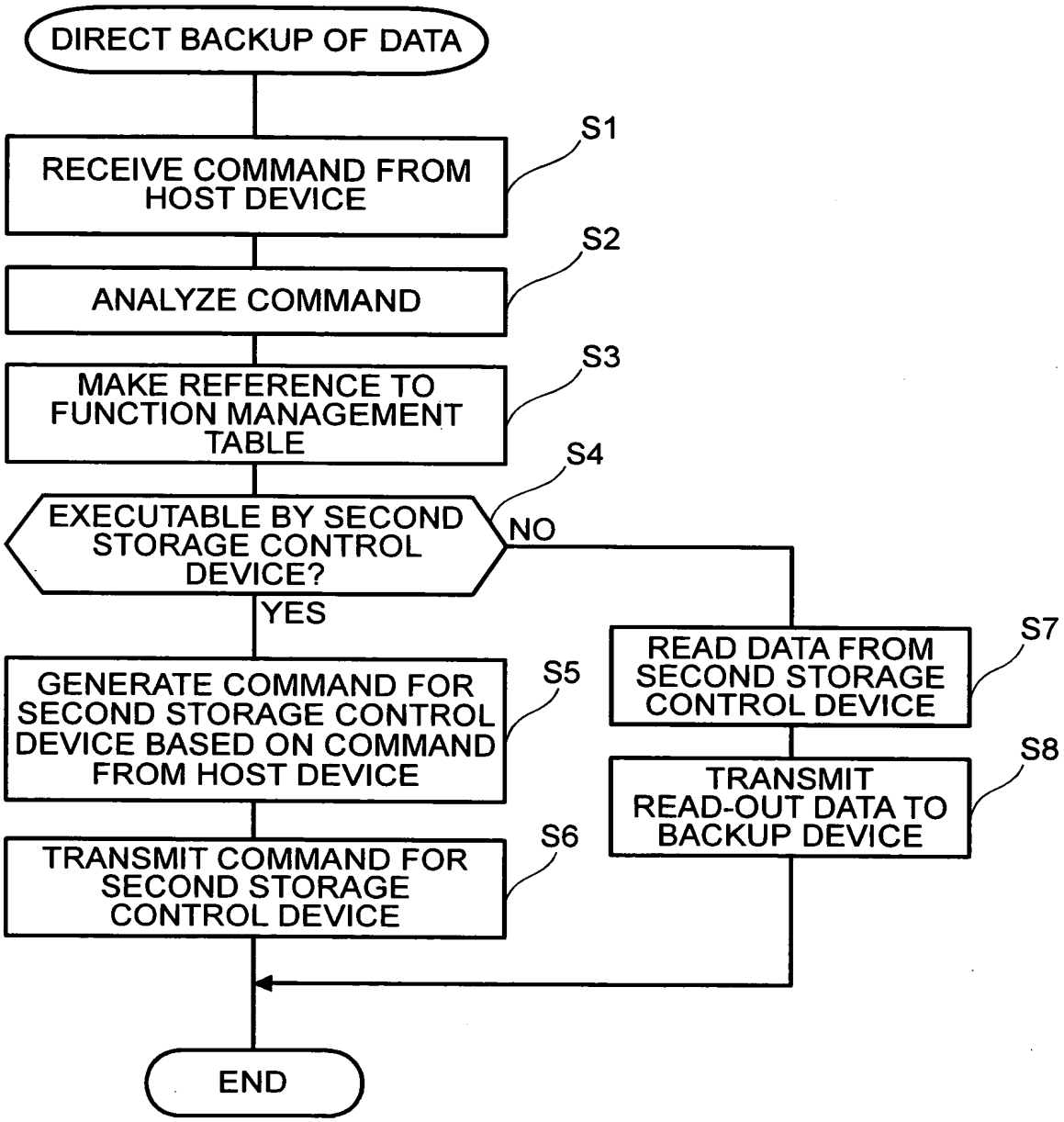

DIRECT BACKUP OF DATA
RECEIVE COMMAND FROM HOST DEVICE
S1
ANALYZE COMMAND
S2
MAKE REFERENCE TO FUNCTION MANAGEMENT TABLE
S3
EXECUTABLE BY SECOND STORAGE CONTROL DEVICE?
S4
NO
YES
GENERATE COMMAND FOR SECOND STORAGE CONTROL DEVICE BASED ON COMMAND FROM HOST DEVICE
S5
TRANSMIT COMMAND FOR SECOND STORAGE CONTROL DEVICE
S6
READ DATA FROM SECOND STORAGE CONTROL DEVICE
S7
TRANSMIT READ-OUT DATA TO BACKUP DEVICE
S8
END

FIG.15

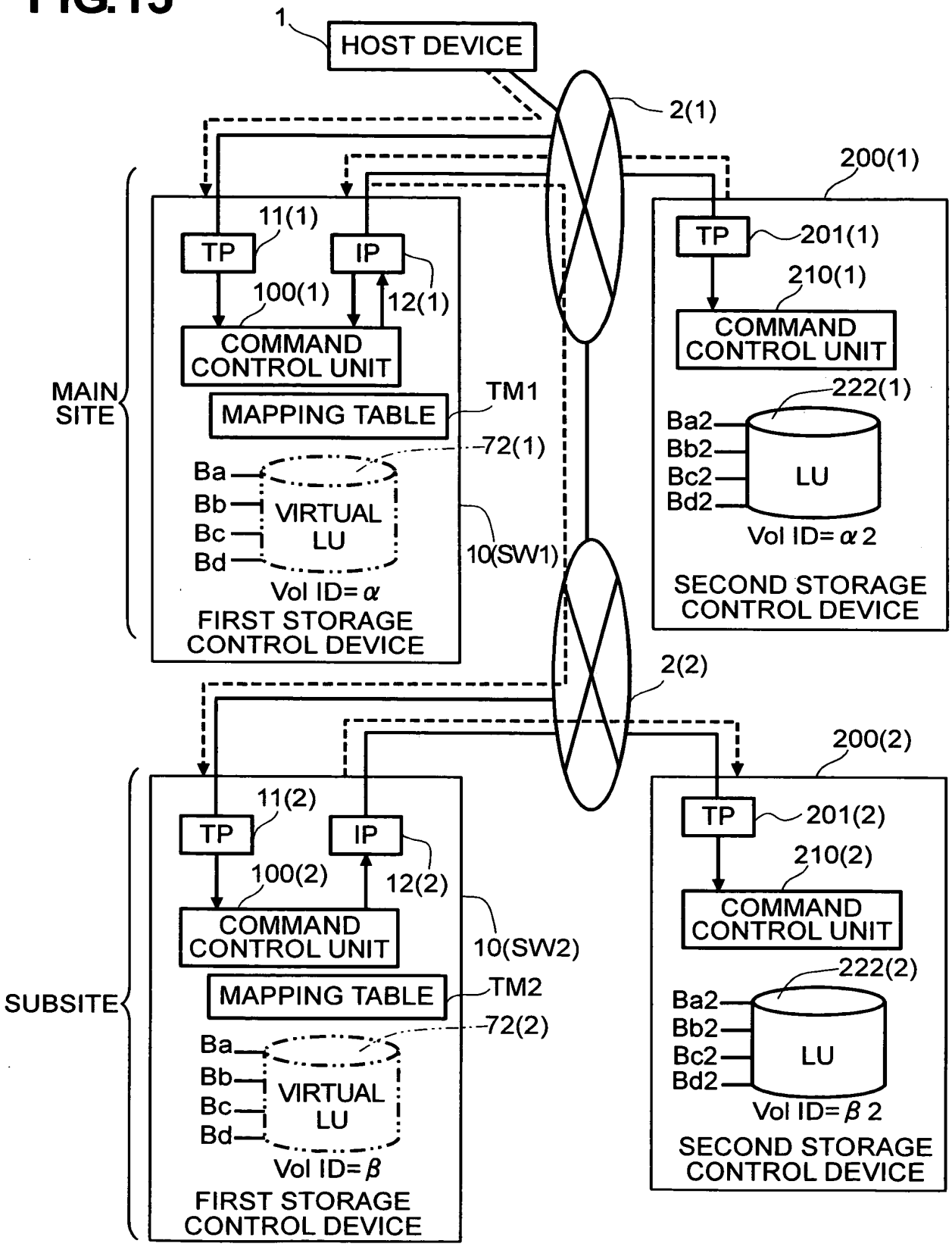

1
HOST DEVICE
2(1)
200(1)
11(1)
TP
IP
100(1)
12(1)
COMMAND CONTROL UNIT
MAPPING TABLE
TM1
72(1)
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID= α
FIRST STORAGE CONTROL DEVICE
MAIN SITE
10(SW1)
TP
201(1)
210(1)
COMMAND CONTROL UNIT
222(1)
Ba2
Bb2
Bc2
Bd2
LU
Vol ID= α 2
SECOND STORAGE CONTROL DEVICE
2(2)
200(2)
11(2)
TP
IP
100(2)
12(2)
COMMAND CONTROL UNIT
10(SW2)
MAPPING TABLE
TM2
72(2)
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID= β
FIRST STORAGE CONTROL DEVICE
SUBSITE
TP
201(2)
210(2)
COMMAND CONTROL UNIT
222(2)
Ba2
Bb2
Bc2
Bd2
LU
Vol ID= β 2
SECOND STORAGE CONTROL DEVICE

FIG.16

(a) EXAMPLE OF MAIN SITE SIDE MAPPING TABLE

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
α	Ba	SD2(1)	TP2(1)	α2	Ba2
⋮	⋮	⋮	⋮	⋮	⋮
α	Bd	SD2(1)	TP2(1)	α2	Bd2

(b) EXAMPLE OF SUBSITE SIDE MAPPING TABLE

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
β	Ba	SD2(2)	TP2(2)	β2	Ba2
⋮	⋮	⋮	⋮	⋮	⋮
β	Bd	SD2(2)	TP2(2)	β2	Bd2

(c) COMMAND STRUCTURE WHEN PERFORMING INITIAL COPY

COMMAND CODE (INITIAL COPY START REQUEST)	ORIGINAL DEVICE ID (SD1(1))	ORIGINAL Vol ID (α)	DESTINATION DEVICE ID (SD1(2))	DESTINATION Vol ID (β)

FIG.17

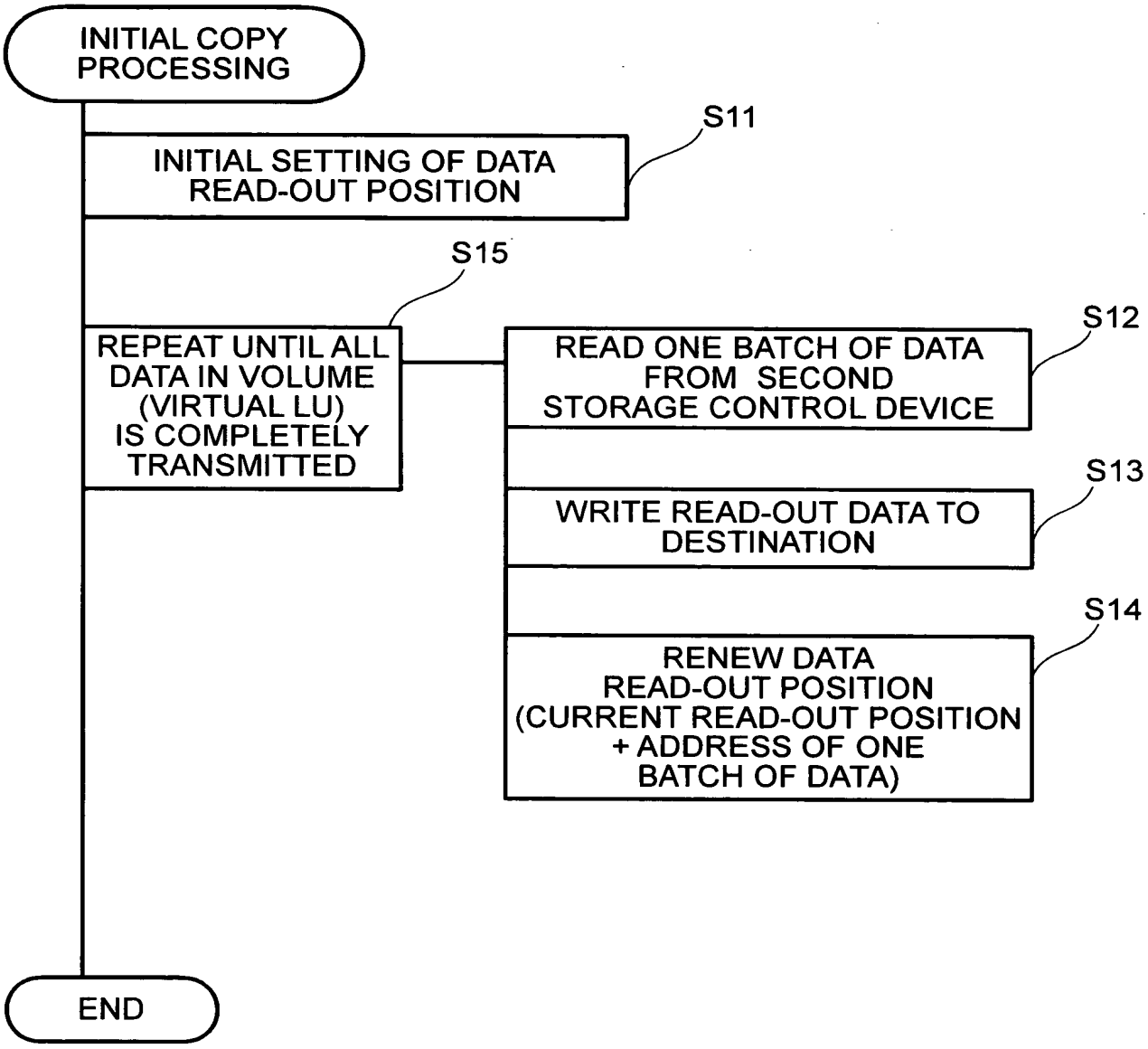

INITIAL COPY PROCESSING
S11
INITIAL SETTING OF DATA READ-OUT POSITION
S15
REPEAT UNTIL ALL DATA IN VOLUME (VIRTUAL LU) IS COMPLETELY TRANSMITTED
S12
READ ONE BATCH OF DATA FROM SECOND STORAGE CONTROL DEVICE
S13
WRITE READ-OUT DATA TO DESTINATION
S14
RENEW DATA READ-OUT POSITION (CURRENT READ-OUT POSITION + ADDRESS OF ONE BATCH OF DATA)
END

FIG.18

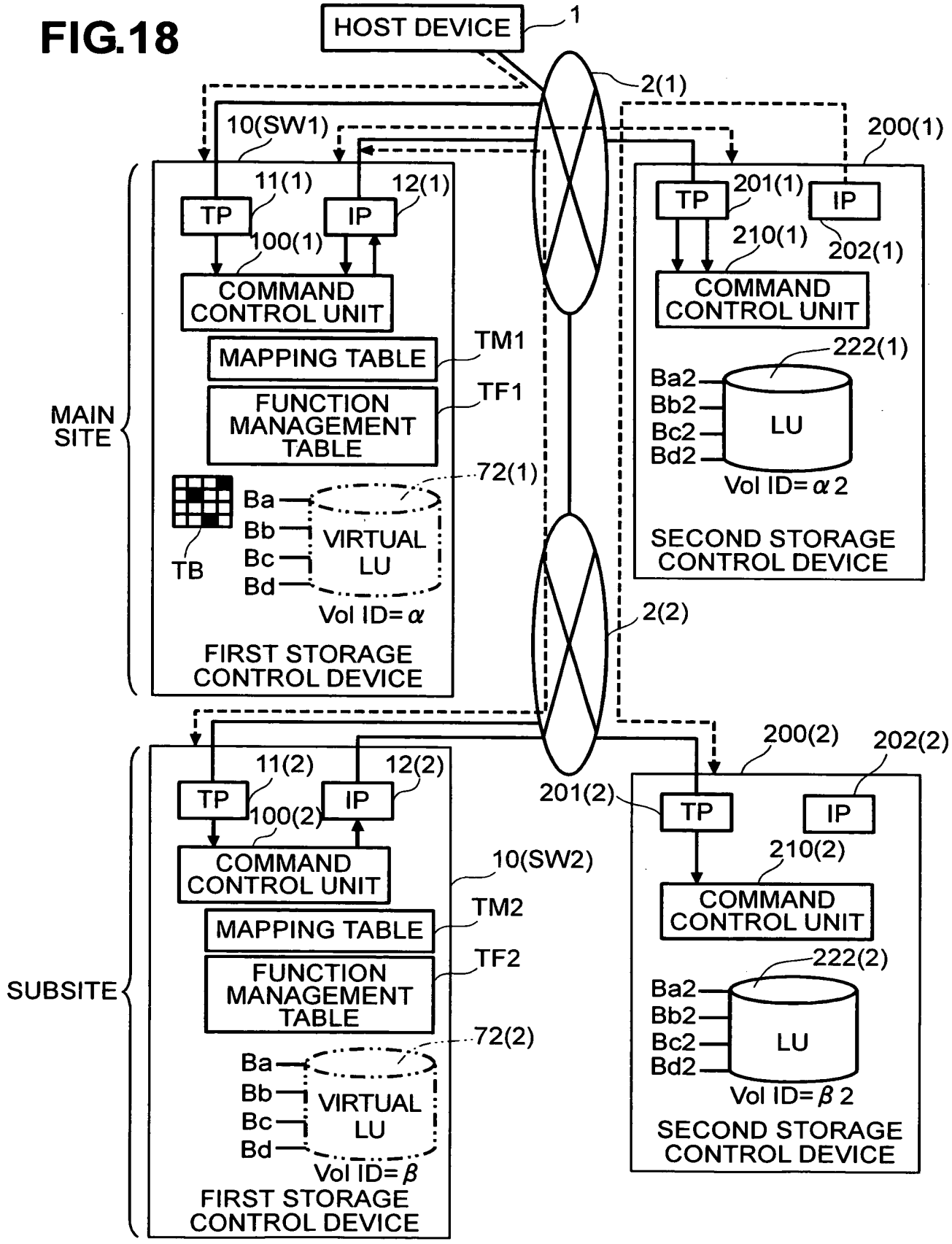

HOST DEVICE
1
2(1)
10(SW1)
200(1)
11(1)
12(1)
TP
IP
100(1)
COMMAND CONTROL UNIT
MAPPING TABLE
TM1
FUNCTION MANAGEMENT TABLE
TF1
MAIN SITE
72(1)
Ba
Bb
Bc
Bd
VIRTUAL LU
TB
Vol ID= α
FIRST STORAGE CONTROL DEVICE
201(1)
210(1)
202(1)
222(1)
Ba2
Bb2
Bc2
Bd2
LU
Vol ID= α 2
SECOND STORAGE CONTROL DEVICE
2(2)
200(2)
202(2)
201(2)
11(2)
12(2)
100(2)
10(SW2)
TM2
TF2
SUBSITE
72(2)
Vol ID= β
210(2)
222(2)
Vol ID= β 2

FIG.19

(a) EXAMPLE OF MAIN SITE SIDE MAPPING TABLE

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
α	Ba	SD2(1)	TP2(1)	α2	Ba2
⋮	⋮	⋮	⋮	⋮	⋮
α	Bd	SD2(1)	TP2(1)	α2	Bd2

(b) EXAMPLE OF SUBSITE SIDE MAPPING TABLE

Vol ID	BLK ADDR	DEVICE ID	Port ID	Vol ID	BLK ADDR
β	Ba	SD2(2)	TP2(2)	β 2	Ba2
⋮	⋮	⋮	⋮	⋮	⋮
β	Bd	SD2(2)	TP2(2)	β 2	Bd2

(c) EXAMPLE OF MAIN SITE SIDE FUNCTION CONTROL TABLE

DEVICE ID	Port ID	SUPPORT FUNCTION F1	SUPPORT FUNCTION F2	···	SUPPORT FUNCTION Fn
SD2(1)	TP2(1)	POSITIVE	NEGATIVE	···	POSITIVE

(d) EXAMPLE OF SUBSITE SIDE FUNCTION CONTROL TABLE

DEVICE ID	Port ID	SUPPORT FUNCTION F1	SUPPORT FUNCTION F2	···	SUPPORT FUNCTION Fn
SD2(2)	TP2(2)	POSITIVE	POSITIVE	···	NEGATIVE

(e) COMMAND STRUCTURE WHEN PERFORMING INITIAL COPY

COMMAND CODE (INITIAL COPY START REQUEST)	ORIGINAL DEVICE ID (SD1(1))	ORIGINAL Vol ID (α)	DESTINATION DEVICE ID (SD1(2))	DESTINATION Vol ID (β)

FIG.20

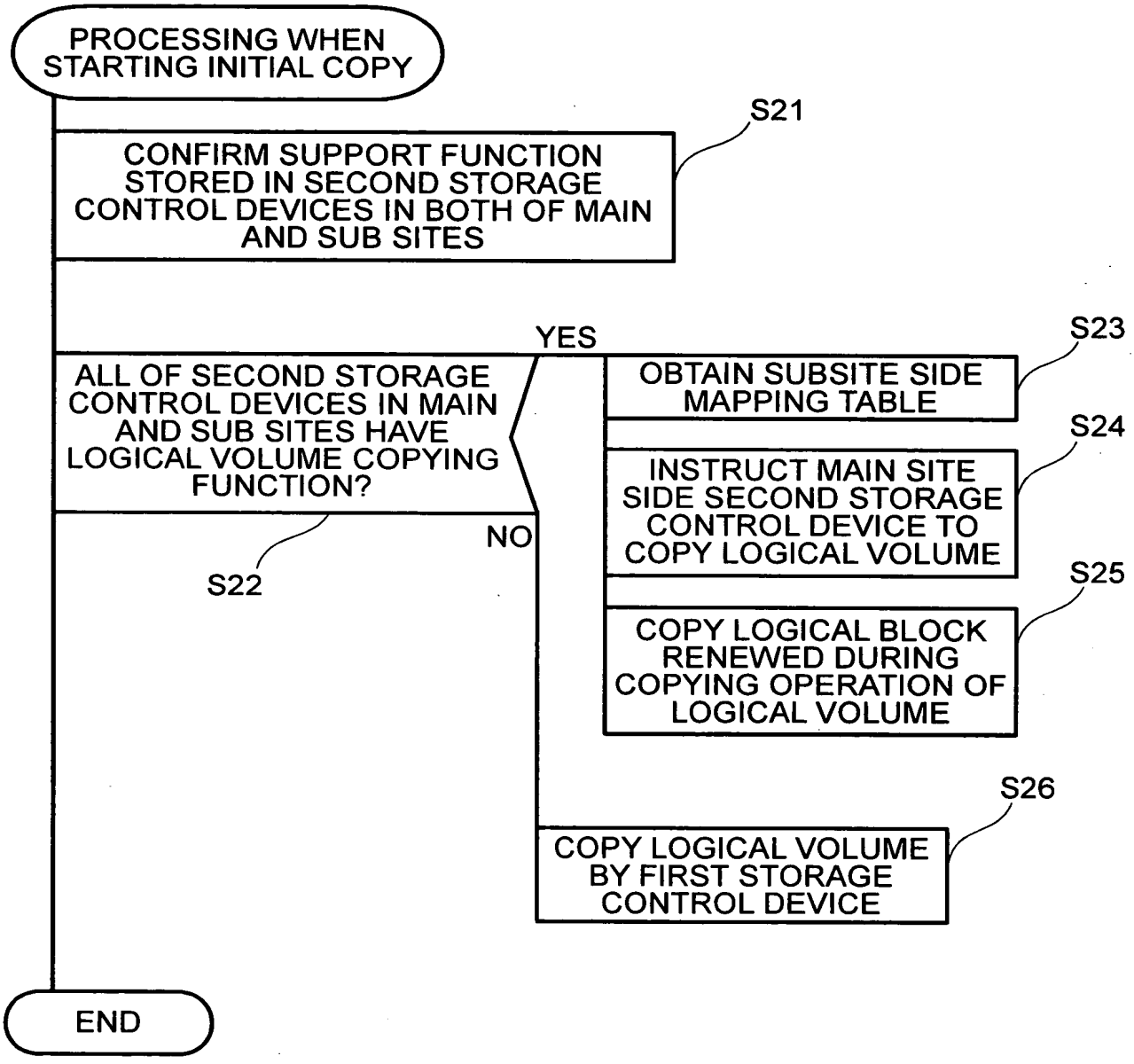

PROCESSING WHEN STARTING INITIAL COPY
S21
CONFIRM SUPPORT FUNCTION STORED IN SECOND STORAGE CONTROL DEVICES IN BOTH OF MAIN AND SUB SITES
YES
ALL OF SECOND STORAGE CONTROL DEVICES IN MAIN AND SUB SITES HAVE LOGICAL VOLUME COPYING FUNCTION?
S23
OBTAIN SUBSITE SIDE MAPPING TABLE
S24
INSTRUCT MAIN SITE SIDE SECOND STORAGE CONTROL DEVICE TO COPY LOGICAL VOLUME
S25
COPY LOGICAL BLOCK RENEWED DURING COPYING OPERATION OF LOGICAL VOLUME
NO
S22
S26
COPY LOGICAL VOLUME BY FIRST STORAGE CONTROL DEVICE
END

FIG.21

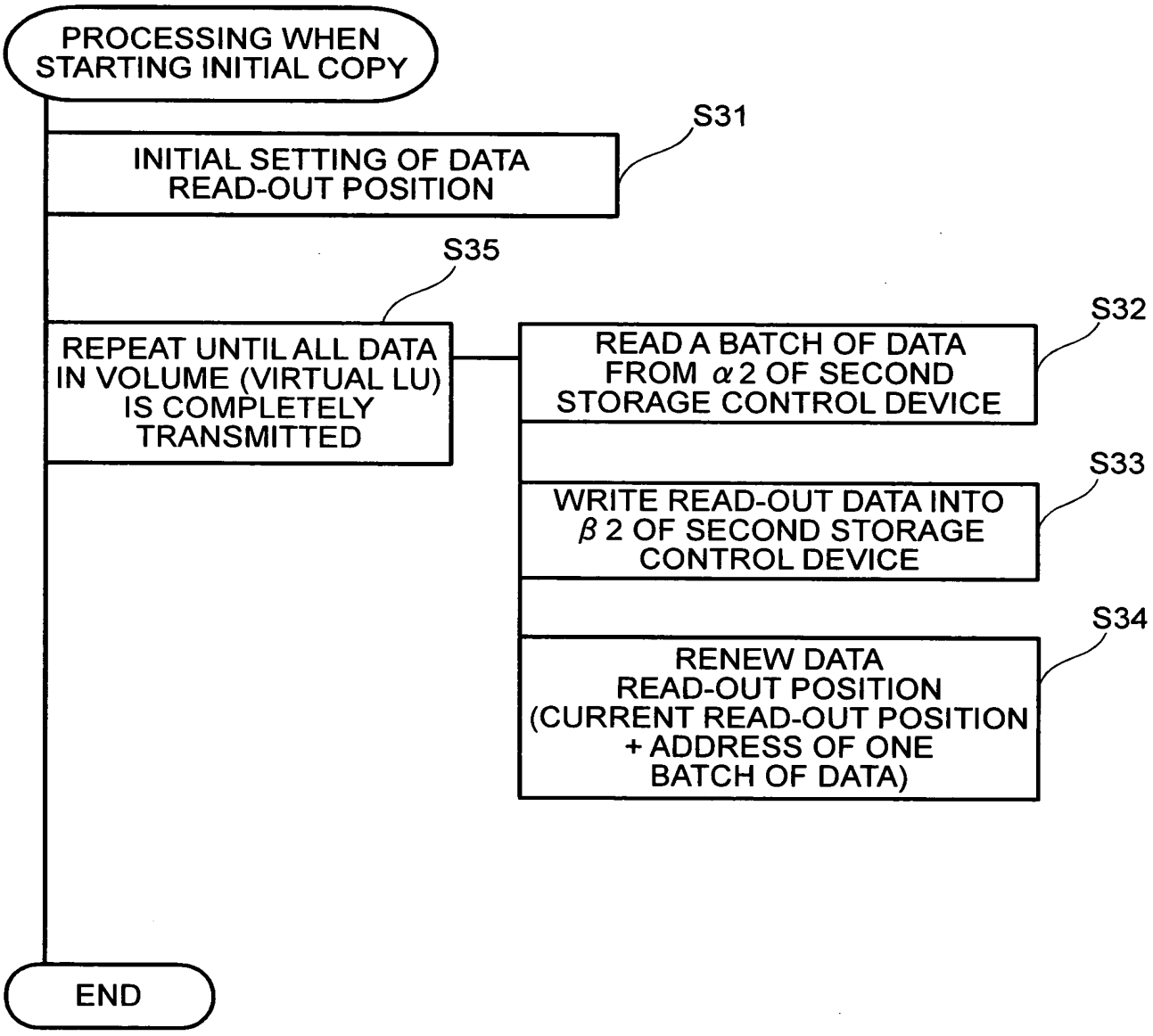
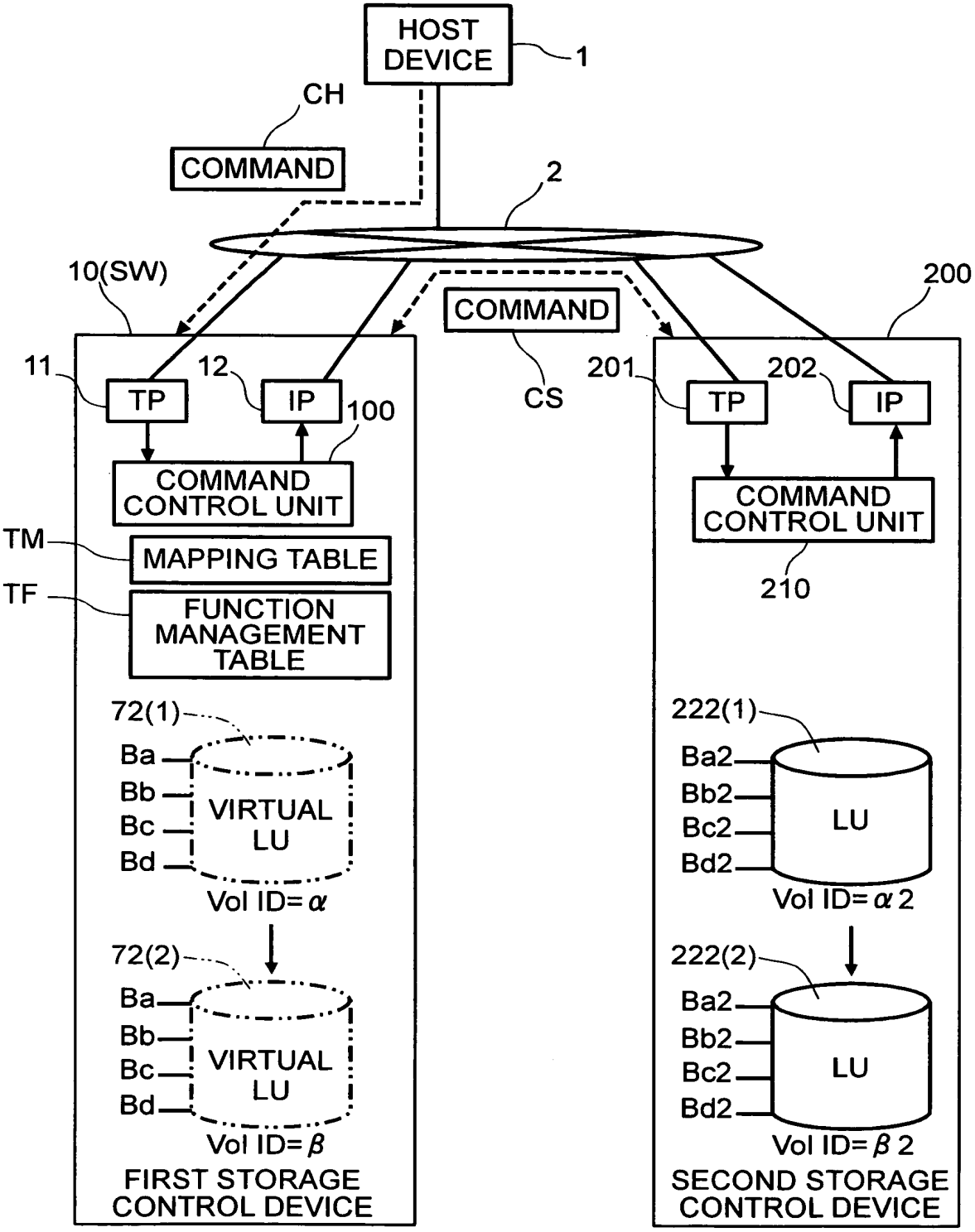

PROCESSING WHEN STARTING INITIAL COPY
S31
INITIAL SETTING OF DATA READ-OUT POSITION
S35
REPEAT UNTIL ALL DATA IN VOLUME (VIRTUAL LU) IS COMPLETELY TRANSMITTED
S32
READ A BATCH OF DATA FROM α2 OF SECOND STORAGE CONTROL DEVICE
S33
WRITE READ-OUT DATA INTO β2 OF SECOND STORAGE CONTROL DEVICE
S34
RENEW DATA READ-OUT POSITION (CURRENT READ-OUT POSITION + ADDRESS OF ONE BATCH OF DATA)
END

FIG.22


HOST DEVICE
1
CH
COMMAND
2
10(SW)
200
COMMAND
CS
11
TP
12
IP
100
201
TP
202
IP
COMMAND CONTROL UNIT
COMMAND CONTROL UNIT
210
TM
MAPPING TABLE
TF
FUNCTION MANAGEMENT TABLE
72(1)
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID=α
72(2)
Ba
Bb
Bc
Bd
VIRTUAL LU
Vol ID=β
FIRST STORAGE CONTROL DEVICE
222(1)
Ba2
Bb2
Bc2
Bd2
LU
Vol ID=α2
222(2)
Ba2
Bb2
Bc2
Bd2
LU
Vol ID=β2
SECOND STORAGE CONTROL DEVICE